Design of on-line monitoring system for acid leakage in chimney

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Abstract

On-line monitoring system for acid leakage in chimney with high practicability and ultra-low power consumption is designed and developed to solve the chimney corrosion problem after wet desulfurization. Firstly, the characteristics of acid leakage are analyzed, and then hardware circuits such as electrode sensing circuit, signal conditioning circuit and data processing unit are designed. In order to reduce polarization losses of sensing wires, direct current is adopted as the power supply of the sensing wire instead of alternating current. In order to reduce operation load and extend service life, program simplification method is adopted in the SCM control logic. Secondly, software functions such as branch alarm display, alarm information record and auxiliary information display are designed. Leakage points can be detected and maintained in time through the designed system, and the purpose of production safety can be achieved by this way.

Keywords

The chimney corrosion, Sensing circuit, MSP430F149, Corrosion warning.

1. Introduction

The removal efficiency of SO3 in flue gas by wet desulfurization process is not high, only about 20%. The flue gas temperature is 40 ~ 50℃ after wet desulfurization without gas heater (GGH), and the flue gas has the characteristics of high saturated moisture content, high humidity and low temperature, so the flue gas is in a cold condensation state [1]. A highly corrosive dilute sulfuric acid is formed after residual SO3 from flue gas is dissolved, because the flue gas runs in the chimney at positive pressure [2].

The flue gas after wet desulfurization also contains strong corrosive substances such as hydrogen fluoride and chloride, which will form a kind of low temperature, high humidity and dilute acid corrosion with high strength, strong permeability and difficult to prevent [3]. Therefore, after wet desulfurization, the potential corrosion of chimney is not eliminated. On the contrary, the flue gas environment after desulfurization will further aggravate the corrosion situation [4].

According to relevant anti-corrosion data of chimneys, the pH value of cold condensation liquid of wet desulfurization chimney is about 2.0, which should be regarded as "high" chemical corrosion grade, that is, strong corrosion grade [5]. It has a strong corrosiveness to chimney structure. It will cause corrosion layer cracking, falling off, corrosion and other damage phenomenon, what is worse, it can endanger the chimney safety.

In order to solve the above problems, this paper developed a system that can on-line monitor the degree of acid corrosion in chimney wall. The corrosion situation of chimney can be judged and the maintenance of chimney also can be arranged in advance through real-time monitoring of acid leakage status. Major safety incidents can be prevented by this way.

2. The System Components

The on-line monitoring system for chimney corrosion mainly includes corrosion sensing units, corrosion data processing unit and corrosion monitoring device, as shown in figure 1.

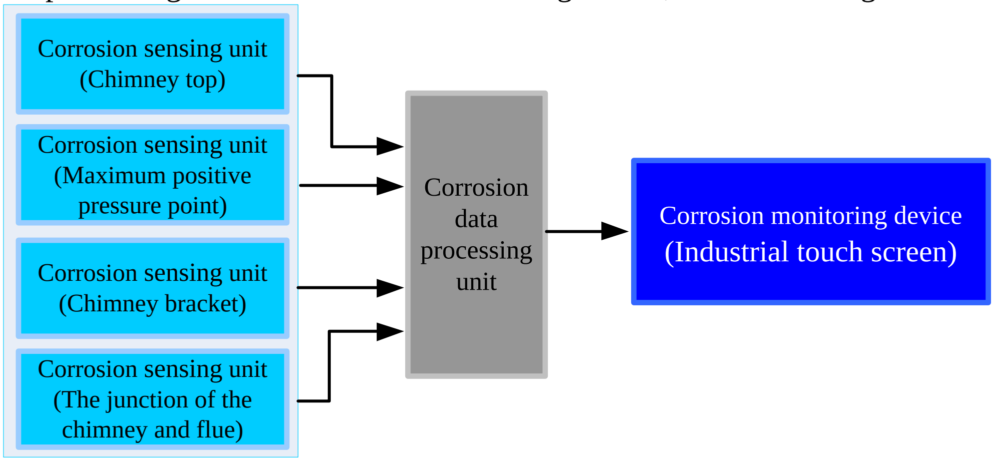

Fig. 1 The structure of on-line monitoring system for chimney corrosion

Acid from the inside of the chimney can be detected by corrosion sensing units installed at corrosion prone locations, including the chimney top, the maximum positive pressure point, the chimney bracket, the junction of the chimney and flue [6]. The detection results of the corrosion sensing unit are transmitted to the corrosion data processing unit through the signal cable. After that, the extent of chimney corrosion can be identified by the corrosion data processing unit. The display and management functions of the results are completed by the chimney corrosion monitoring device.

3. The Design of System Hardware

3.1 Hardware system composition

The ultra-low power microcontroller MSP430F149 is selected as the core of the system [7]. The detection of the location and quantity of acid leakage in the inner wall of the chimney can be realized through signal acquisition, computer processing, display and alarm of the upper computer.

The system hardware is mainly composed of sensor circuit, signal conditioning circuit, auxiliary power circuit, control circuit, alarm and HMI.

The collection and conversion of leakage information from the chimney wall is completed by sensors. The conversion process of voltage signal output by sensor is completed by signal conditioning circuit, which is collected and judged by single chip microcomputer. The safe power supply of each module of the system is realized by the auxiliary power supply module. The information processing and alarm display uploaded from the control board are completed by HMI, as shown in figure 2.

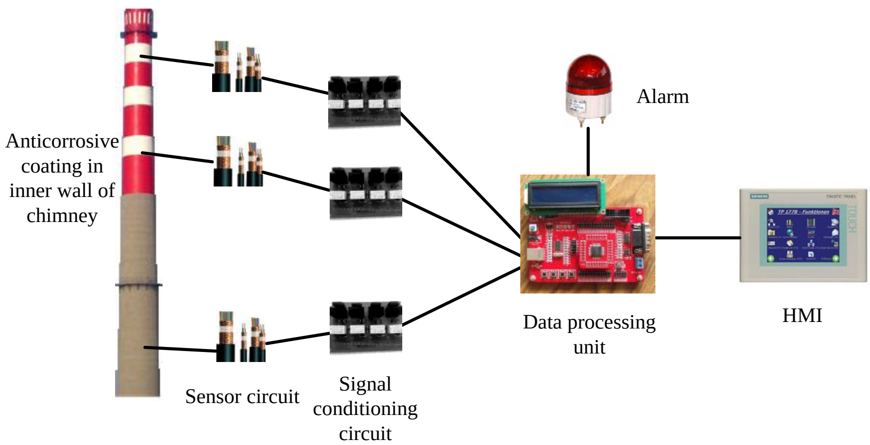

Fig. 2 Hardware structure of System

3.2 Sensor Circuit

The leakage of the anticorrosive coating in the inner wall of the chimney is a state information with physical and chemical properties, rather than a purely physical or chemical signal in the traditional sense. This state information is what the system needs to detect and is similar to a switch quantity. This special state information needs to be studied before it is collected.

The acid inside the coating is a strong electrolyte and has good conductivity because it usually contains a lot of plasma. Therefore, when leakage occurs, the area inside the anticorrosive coating eroded by acid will have the same ionic potential [8]. Therefore, the detection method is as follows, two metal electrodes are embedded in the inner area of the anticorrosive coating, and one electrode is set at high potential. Two metal electrodes will conduct due to the conductivity of the electrolyte when leakage occurs, and then the potential of one electrode is pulled up. Whether there is acid leakage and the location of the leakage point can be determined by the change of electrode potential. The electrode sensor can form a complete detection sensor circuit for nonelectric quantity data with appropriate conversion circuit.

In order to reduce the loss of electrode material caused by electrode polarization, 50Hz low-frequency alternating current is used as the power supply for the electrode sensor, and the service life of the electrode sensor is extended by means of continuous change of electrode polarity.

3.3 Signal Conditioning Circuit

The signal conditioning circuit consists of auxiliary power supply and signal input circuit. The auxiliary power supply provides power for other modules in the system. The electrode sensing circuit uses 36V alternating current, and the data processing unit uses 5V direct current.

The signal input circuit plays the function of voltage conversion between the sensor circuit and the data processing unit. Since the electrode sensing circuit uses 36V ac power supply and uses the short circuit signal of parallel electrode as the input detection signal, the output voltage is 36V ac. The signal input circuit, which can enable the data processing unit to safely receive the output signal of the sensor circuit, is designed, because the MSP430F149 single-chip microcomputer is allowed to apply the dc voltage value shall not exceed 3.3v. The signal input circuit converts 36V AC to 3.3v DC before input to the corresponding port of data processing unit.

Twenty signal input circuits were designed because the system had a total of 20 detection points, namely, 20 sets of parallel electrodes placed inside the chimney wall.

The signal input circuit is similar to the DC power module. The signal input circuit is composed of integrated rectifier bridge KBP307, general small integrated power module WRF4805S-3WR2 and 3.3V general integrated voltage regulator AMS1117. Figure 3 shows part of the signal conditioning circuit.

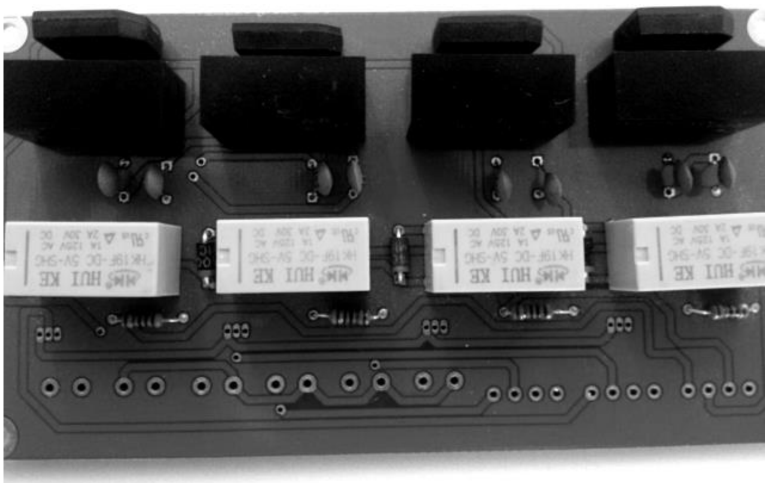

Fig. 3 Parts of Signal Conditioning Circuit

3.4 Data Processing Unit

The data processing unit is the control circuit of the system, and the MSP430 series single-chip microcomputer is the processor of the data processing unit. All the data of the system are controlled and processed by this unit.

I/O and UART modules, two peripherals of MSP430, are important parts of data processing and control functions of the system.

The potential status signal of the signal input circuit is received and processed by the I/O interface of the data processing circuit, and whether there is any acid leakage is judged by the processor, and then the alarm circuit is triggered through the corresponding I/O interface.

The communication between data processing unit and WECON HMI is carried out through UART module, that is, asynchronous serial communication and HIMI is carried out through RS485 interface according to USS protocol. Figure 4 shows data processing unit.

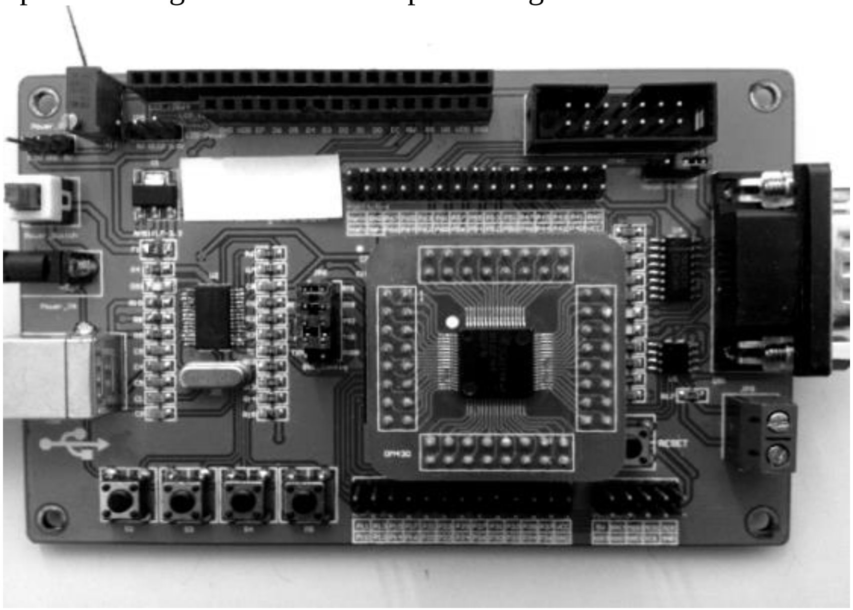

Fig. 4 Data Processing Unit

3.5 HMI

HMI is an important part of the detection system, which can realize the exchange between user usage patterns and internal forms of data. HMI is used to display the detection results of the system and conduct man-machine interaction to complete the information exchange between the system and users. HMI USES the industrial-grade human-machine interface product produced by WECON as the development hardware, and develops the system configuration software in combination with the Levistudio configuration development environment. Figure 5 shows HMI of WECON.

Fig. 5 HMI of WECON(Levi777A)

4. The Design of System Software

The on-line monitoring system for chimney corrosion shall have the following functions

(1)Detection data uploaded by the data processing unit can be processed; The detection data of each branch can be displayed in real time by the 20-channel alarm display lamp set on the interface; The display light should be changed and accompanied by voice prompts when there is leakage in a branch;

(2)The alarm information of each branch should be recorded through the alarm history bar designed in the software, which is convenient for system operators to call and view.

(3)The system restart key should be designed. The system can be restarted by sending restart instructions to the data processing unit, which is operated by field operators on the HMI.

(4)The auxiliary information display bar should be designed. Parameters such as rated voltage, current, power, and considerations for the system operating environment can be displayed on the interface.

4.1 Branch Alarm Display

The alarm data of the 20 branches is stored in a column of registers after the HMI receives the data uploaded by the data processing unit. The 20-bit switch is designed on the interface, and the monitoring address of the set bit switch is the same as the storage address of the corresponding alarm branch data. Bit switch action occurs when register value is 1. The real-time display of 20-channel detection information can be realized by 20 alarm display lights through the above methods. The interface design of alarm lamp is shown in figure 6.

Fig. 6 Display interface of alarm lamp

Fig. 7 Alarm history column

4.2 Alarm History Record and Auxiliary Information Display.

HMI can jump to the alarm history list by touching the corresponding button, and the alarm data of acid leakage occurring within a period of time can be displayed in the alarm history list. Alarm data comes from registers that can be stored after function switch Settings are completed. The interface of the alarm history list is shown in figure 7. The configuration method of auxiliary information display bar is the same as that of alarm information bar. The equipment operating environment, technical parameters and operating considerations are given in the auxiliary information. The interface of the auxiliary information is shown in figure 8.

Fig. 8 Auxiliary information display display

5. Conclusion

In this paper, a practical on-line monitoring system for chimney corrosion with low power consumption is designed and developed. The ultra-low power microcontroller MSP430F149 is selected as the control chip. In order to reduce polarization losses of sensing wires, direct current is adopted as the power supply of the sensing wire instead of alternating current. In order to reduce operation load and extend service life, program simplification method is adopted in the SCM control logic.

Leakage points can be found and repaired in a timely, and damage to the anticorrosive coating can be reduced through the designed online monitoring system for chimney corrosion. A safe, stable, reliable and low-input chimney leakage on-line monitoring and early warning system can be effectively implemented through the system. The work cycle of maintenance personnel can be shortened, the loss caused by chimney leakage can be avoided, the purpose of production safety can be achieved, and the needs of domestic and foreign enterprises can be met.

Acknowledgements

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